

FINAL REPORT for NAG5-7359 (OSP 6701100)
Submitted by
Alan J. Lazarus
Senior Research Scientist, MIT Center for Space Research

Introduction

The construction of the Faraday Cup portion of the SWIE instrument on the Wind spacecraft, participation in Mission Operations, and Data Analysis (MO & DA) of observations of the solar wind has been supported by a sequence of grants. This "final" Report represents work done on Mission Operations and Data Analysis for the Faraday Cup portion of the SWE.

The work reported here was supported under NASA Grant NAG5-7359 (OSP 6701100) from June 1998 to October 2001. It should be noted that this work is continuing under NASA Grant NAG-10915, and therefore this report is "final" only in the sense that the Grant has changed its number; a future report will cover the entire period of work.

We have two types of obligations under these contracts:

1. To provide and assure the validity of "Key Parameters" which describe the basic properties of the solar wind on a daily basis. We have provided our 92-second observations daily via plots and parameters available from our Web site: <http://web.mit.edu/space/www/wind/wind.html>

2. To carry out scientific studies based on our observations. To document the extent of our research, we are including below a list of publications and presentations related to this project. The observations from Wind have made a major contribution to the study of the solar wind, and have every indication of continuing to do so.

Publications

Burlaga, L., R. Fitzenreiter, R. Lepping, K. Ogilvie, A. Szabo, A. Lazarus, J. Steinberg, G. Gloeckler, R. Howard, D. Michels, C. Farrugia, R. P. Lin, and D. E. Larson, A magnetic cloud containing prominence material: January 1997, *J. Geophys. Res.*, 103, 277-285, 1998.

Crooker, N. U., A. H. McAllister, R. J. Fitzenreiter, J. A. Linker, D. E. Larson, R. P. Lepping, A. Szabo, J. T. Steinberg, A. J. Lazarus, Z. Mikic, and R. P. Lin, Sector boundary transformation by an open magnetic cloud, *J. Geophys. Res.*, 103, 26,859-26,868, 1998.

Fairfield, D. H., T. Mukai, A. T. Y. Lui, C. A. Cattell, G. D. Reeves, T. Nagai, G. Rostoker, H. J. Singer, M. L. Kaiser, S. Kokubun, A. J. Lazarus, R. P. Lepping, M. Nakamura, J. T. Steinberg, K. Tsuruda, D. J. Williams, and T. Yamamoto, Geotail observations of substorm onset in the inner magnetotail, *J. Geophys. Res.*, 103, 103-117, 1998.

Farrell, W. M., M. L. Kaiser, J. T. Steinberg, and S. D. Bale, A simple simulation of a plasma void: Applications to Wind observations of the lunar wake, *J. Geophys. Res.*, 103, 23,653-23,660, 1998.

Farrugia, C. J., J. D. Scudder, M. P. Freeman, L. Janoo, G. Lu, J. M. Quinn, R. L. Arnoldy, R. B. Torbert, L. F. Burlaga, K. W. Ogilvie, R. P. Lepping, A. J. Lazarus, J. T. Steinberg, F. T. Grutton, and G. Rostoker, Geoeffectiveness of three WIND magnetic clouds: A comparative study, *J. Geophys. Res.*, 103, 17,261-17,278, 1998.

Gibson, S. E., D. Biesecker, M. Guhathakurta, J. T. Hoeksema, A. Lazarus, J. Linker, Z. Mikic, Y. Pisanko, P. Riley, J. Steinberg, L. Strachan, A. Szabo, B. Thompson, and X. P. Zhao, The three-dimensional coronal magnetic field during Whole Sun Month, *Ap.J.* 520 (2): 871-879 Part 1, 1999.

Lazarus, A. J., and K. I. Paularena, A comparison of solar wind parameters from experiments on the IMP 8 and Wind spacecraft, in *Measurement Techniques in Space Plasmas: Particles, Geophysical Monograph 102*, R. F. Pfaff, J. E. Borovsky, D. T. Young, eds. American Geophysical Union, Washington, D.C. 85-90, 1998.

Neugebauer, M., R. J. Forsyth, A. B. Galvin, K. L. Harvey, J. T. Hoeksema, A. J. Lazarus, R. P. Lepping, J. A. Linker, Z. Mikic, J. T. Steinberg, R. von Steiger, Y.-M. Wang, and R. F. Wimmer-Schweingruber, Spatial structure of the solar wind and comparisons with solar data and models, *J. Geophys. Res.*, 103, 14,587-14,599, 1998.

Sanderson, T. R., R. P. Lin, D. E. Larson, M. P. McCarthy, G. K. Parks, J. M. Bosqued, N. Lormant, K. Ogilvie, R. P. Lepping, A. Szabo, A. J. Lazarus, J. Steinberg, and J. T. Hoeksema, Wind observations of the influence of the Sun's magnetic field on the interplanetary medium at 1 AU, *J. Geophys. Res.*, 103, 17,235-17,247, 1998.

Tsyganenko, N. A., S. B. P. Karlsson, S. Kokubun, T. Yamamoto, A. J. Lazarus, K. W. Ogilvie, C. T. Russell, and J. A. Slavin, Global configuration of the magnetotail current sheet as derived from GEOTAIL, WIND, IMP-8, and ISEE 1/2 data, *J. Geophys. Res.*, 103, 6827-6841, 1998.

Villante, U., P. Francia, S. Lepidi, M. De Lauritis, E. Pietropaolo, L. Cafarella, A. Meloni, A. J. Lazarus, R. P. Lepping, and F. Mariani, Geomagnetic field variations at low and high latitude during the January 10-11, 1997 magnetic cloud, *Geophys. Res. Lett.*, 25, 2593-2596, 1998.

Zastenker, G. N., P. A. Dalin, A. J. Lazarus, and K. I. Paularena, Comparison of solar wind parameters measured simultaneously by several spacecraft, *Cosmic Research*, 36, 214-225, 1998. Also *Kosmich. Issle.* (in Russian), 36, 3, 228-240, 1998.

Breen, A. R., Z. Mikic, J. A. Linker, A. J. Lazarus, B. J. Thompson, D. A. Biesecker, P. J. Moran, C. A. Varley, P. J. S. Williams, and A. Lecinski, Interplanetary scintillation measurements of the solar wind during Whole Sun Month: Comparisons with coronal and in situ observations, *J. Geophys. Res.*, 104, 9847-9870, 1999.

Nikolaeva, N. S., G. N. Zastenker, M. N. Nozdrachev, A. A. Skalsky, N. A. Eismont, J. Safrankova, Z. Nemecek, O. Santolik, J. Steinberg, A. Lazarus, A. Szabo, R. Lepping, J.-H. Shue, J. Borovsky, M. Thomsen, and L. Frank, Position and motion of the magnetopause during arrival of a magnetic cloud to the Earth on January 10 and 11, 1997, *Cosmic Research*, 36, Also *Kosmich. Issle.* (in Russian) 36 (6), 564-575, 1999, 526-536, 1999.

Posner, A., V. Bothmer, H. Kunow, J. T. Gosling, B. Heber, A. J. Lazarus, J. A. Linker, R. J. Marsden, Z. Mikic, R. Muller-Mellin, T. R. Sanderson, A. Szabo, and B. J. Thompson, Energetic particle signatures of a corotating interaction region from a high latitude coronal hole: SOHO, Wind and ULYSSES observations, *Adv. Space Res.*, 26, (5), 865-870, 2000.

Posner, A., V. Bothmer, B. J. Thompson, H. Kunow, B. Heber, R. Muller-Mellin, A. J. Lazarus, A. Szabo, Z. Mikic, and J. A. Linker, In-ecliptic CIR-associated energetic particle events and polar coronal hole structures: SOHO/COSTEP observations for the Whole Sun Month Campaign, *J. Geophys. Res.*, 104, 9881-9890, 1999.

Zastenker, G. N., P. A. Dalin, A. A. Petrukovich, M. N. Nozdrachev, S. A. Romanov, K. I. Paularena, J. D. Richardson, A. J. Lazarus, R. P. Lepping, and A. Szabo, Solar wind structure by multipoint observations, *Phys. Chem. Earth*, 25, 137-140, 1999.

Zastenker, G. N., M. N. Nozdrachev, J. Safrankova, Z. Nemecek, K. I. Paularena, A. J. Lazarus, R. P. Lepping, and T. Mukai, Fast solar wind plasma and magnetic field variations in the magnetosheath, *Czech J. Phys.*, 49, 579-590, 1999.

Breen, A. R., B.J. Thompson, M. Kojima, D. A. Biesecker, A. Canals, R. A. Fallows, J.A. Linker, A. J. Lazarus, A. Lecinski, Z. Mikic, P.J. Moran, P.J. S. and Williams, Measurements of the solar wind over a wide range of heliocentric distances - a comparison of results from the first three Whole Sun Months, *J. Atm. Solar Terr. Phys.*.. 62, 1527-1543, 2000.

Burlaga, L. F. and A. J. Lazarus, Lognormal distributions and spectra of solar wind plasma fluctuations: Wind 1995-1998, *J. Geophys. Res.*, 105, 2357-2364, 2000.

Fairfield, D.H., A. Otto, T. Mukai, S. Kokubun, R. P. Lepping, J. T. Steinberg, A. J. Lazarus, and T. Yamamoto, Geotail observations of the Kelvin-Helmholz instability at the equatorial magnetotail boundary for parallel northward field, *J. Geophys. Res.*, 105, 21,159-21, 173, 2000.

Lazarus, A. J., The Day the Solar Wind Almost Disappeared, *Science*, 287 , 2172, 2173, 2000.

Russell, C.T., Y. L. Wang, J. Raeder, C.W. Smith, K. W. Ogilvie, A. J. Lazarus, R.P. Lepping, A. Szabo, H. Kawano, T. Mukai, S. Savin, Y.I. Yermolaev, X.-Y. Zhou, and B.T. Tsurutani, The interplanetary shock of September 24, 1998: Arrival at Earth, *J. Geophys Res.*, 105, 25, 143-25,154, 2000.

Zastenker, G. N. P. A. Dalin, A. A. Petrukovich, M .N. Nozrachev, S. A. Romanov, K. I. Paularena, J.D. Richardson, A.J. Lazarus, R.P. Lepping, A. J. Szabo, Solar wind structure dynamics by multipoint observations, *Phys. Chem Earth C: Solar Terr.. Plan Sci.*, 25, 137-140, 2000.

Zhou,X.-Y, B.T. Tsurutani, W. D., Gonzalez, A. J. Lazarus, The Solar Wind Depletion Event of 26 April 1999: Triggering of an annual "pseudobreakup event", *J. Geophys. Res.*, 27, 4025, 2000.

Aellig, M. R., A. J., Lazarus, J. C. Kasper, K. W. Ogilvie, Rapid Measurements of Solar Wind Ions with the Triana Plasmag Faraday Cup, *Astrophys. Sp. Sci.*, 277, 305-307, 2001.

Aellig, M.R., A. J. Lazarus, and J. T. Steinberg, The solar wind helium abundance over the solar cycle, *Geophys. Res. Lett.*, 28, 14, 2767-2770, 2001.

Aellig, M. R., A.. J. Lazarus, and J. T. Steinberg, The solar wind helium abundance over the solar cycle, SOHO-ACE Workshop on Solar and Galactic Composition, March 6 - 9, Bern, Switzerland, AIP Conference Proceedings, 598, 89, 2001,

Coplan, M. A., F., Ipvich, J. King, K. W. Ogilvie, D .A. Roberts, A. J. Lazarus, Correlation of solar wind parameters between SOHO and Wind, *J. Geophys. Res.*, 105, 18, 615, 2001.

Talks and Presentations

Coplan, M. A., M. Holland, F. Ipvich, K. W. Ogilvie, A. J. Lazarus, and J. T. Steinberg, Solar wind plasma cross correlations between the SOHO and WIND spacecraft, *Fall Meeting, American Geophysical Union*, San Francisco, California, December 6-10, 1998.

Dalin, P., G. Zastenker, K. Paularena, J. D. Richardson, and A. J. Lazarus, Study of the solar wind plasma structures using the space observations, *5th Open Young Scientists' Conference on Astronomy and Space Physics*, Kyiv Shevchenko University Astronomy and Space Physics Department, Kiev, Ukraine, April 27-30, 1998.

Farrugia, C. J., L. Janoo, R. B. Torbert, J. M. Quinn, K. W. Ogilvie, R. P. Lepping, R. J. Fitzenreiter, R. P. Lin, D. Larson, J. T. Steinberg, A. J. Lazarus, D. Berdichevsky, and Y. Lin, A hot magnetic flux rope in the solar wind, *Solar Wind 9*, Nantucket, Massachusetts, October 4-9, 1998.

Gosling, J. T., D. J. McComas, D. Reisenfeld, J. T. Steinberg, P. Riley, and A. J. Lazarus, Solar wind evolution between 1 and 5.4 AU: A global analysis of Ulysses and Wind observations, *EOS* 79, F724-725, 1998.

Lazarus, A. J., A search for the sources of high-speed solar wind streams: Whole Sun Month observations, invited talk, *EOS* 79, S278, 1998.

Lazarus, A., R. Decker, F. McDonald, and J. Richardson, Corotating interaction regions in the outer heliosphere: Evidence from the solar wind and cosmic rays, *Solar Wind 9*, Nantucket, Massachusetts, October 4-9, 1998.

Posner, A., V. Bothmer, H. Kunow, B. Heber, R. Muller-Mellin, B. J. Thompson, A. J. Lazarus, A. Szabo, and Z. Mikic, In-ecliptic CIR-associated energetic particle events and polar coronal hole structures: SOHO observations for the Whole Sun Month campaign, poster, *EOS* 79, S283, 1998.

Sanderson, T. R., M. Maksimovic, M. P. McCarthy, G. K. Parks, R. P. Lin, D. Larson, J. M. Bosqued, N. Lormant, A. J. Lazarus, J. Steinberg, R. P. Lepping, A. Szabo, M. Kaiser, J. T. Hoeksema, and J. L. Bougeret, Interplanetary conditions during the first three years of WIND, *Yosemite '98 conference, Toward Solar Max 2000: Present Achievements and Future Opportunities of ITSP and GEM*, Yosemite National Park, February 10-13, 1998.

Smith, C. W., N. F. Ness, R. J. Leamon, L. F. Burlaga, M. H. Acuna, M. R. Collier, W. C. Feldman, A. J. Lazarus, and J. T. Steinberg, ACE/WIND comparisons of interplanetary measurements, invited talk, *EOS* 79, S299, 1998.

Steinberg, J. T., G. C. Ho, A. J. Lazarus, D. C. Hamilton, G. Gloeckler, K. W. Ogilvie, and R. P. Lepping, Solar wind He^{++} enhancements and other minor ion abundances in large ejecta: A WIND study, *EOS* 79, S286-287, 1998.

Szabo, A., R. P. Lepping, R. J. Fitznerreiter, J. T. Steinberg, K. I. Paularena, and A. J. Lazarus, Multi-spacecraft observations of interplanetary shocks, *EOS* 79, S283, 1998.

Zastenker, G., P. Eiges, N. Borodkova, Yu. Yermolaev, V. Lutsenko, M. Nozdrachev, Ja. Safrankova, Z. Nemecek, K. Paularena, A. Lazarus, A. Szabo, R. Lepping, T. Mukai, S. Kokubun, and D. Sibeck, INTERBALL observations in the foreshock and comparison with IMP 8, Wind and GEOTAIL, 1998 COSPAR Meeting, Nagoya, Japan, July 12-19, 1998.

Zastenker, G., P. Dalin, K. Paularena, J. Richardson, A. Lazarus, and F. Dashevskiy, Solar wind correlation features by multi-spacecraft study, 1998 COSPAR Meeting, Nagoya, Japan, July 12-19, 1998.

Zastenker, G. N., P. A. Dalin, A. A. Petrukovich, M. N. Nozdrachev, S. A. Romanov, K. I. Paularena, J. D. Richardson, A. J. Lazarus, R. P. Lepping, and A. Szabo, Solar wind structure dynamics by multipoint observations, *International Symposium, Space Plasma Studies by In-Situ and Remote Measurements*, Space Research Institute of the Russian Academy of Sciences, Moscow, Russia, June 1-5, 1998.

Zastenker, G. N., P. E. Eiges, P. A. Dalin, M. N. Nozdrachev, J. Safrankova, Z. Nemecek, K. I. Paularena, J. D. Richardson, A. J. Lazarus, R. P. Lepping, T. Mukai, S. Kokubun, and D. G. Sibeck, Foreshock and magnetosheath plasma structures study by ISTP spacecraft correlated data: IMP 8, Wind, GEOTAIL, INTERBALL-1 and MAGION-4, invited talk, *EOS* 79, S300, 1998.

Aellig, M. R., A. J. Lazarus, and J. T. Steinberg, The helium abundance in the solar wind measured with Wind/SWE, *EOS* 80, S257, 1999.

Berdichevsky, D. B., R. P. Lepping, A. Szabo, L. F. Burlaga, B. J. Thompson, A. J. Lazarus, J. T. Steinberg, and F. Mariani, Some peculiar properties of magnetic clouds as observed by the Wind spacecraft, *EOS* 80, S260, 1999.

Breen, A. R., R. A. Fallows, P. J. Moran, P. J. S. Williams, Z. Mikic, J. A. Linker, J. T. Hoeksema, M. Kojima, A. J. Lazarus, B. J. Thompson, and D. Biesecker, Fast and slow streams of solar wind: Using coronal models to improve the accuracy of interplanetary scintillation measurements, presented at the *European Geophysical Society Meeting*, Spring, 1999.

Dalin, P. A., A. J. Lazarus, G. N. Zastenker, A. N. Zaitsev, V. I. Odintso, and D. G. Sibeck, Ion flux (pressure) pulses in the solar wind observed from the INTERBALL-1, Wind and other spacecraft. Part 2. Magnetosheath passes and geomagnetic sequencies, *Dynamics of the Magnetosphere (INTERBALL)* conference, Zvenigorod, Russia, February 8-13, 1999.

Eiges, P. E., G. N. Zastenker, M. N. Nozdrachev, J. Safrankova, Z. Nemecek, V. Hraban, K. I. Paularena, A. J. Lazarus, R. P. Lepping, T. Mukai, and S. Kokubun, Multispacecraft solar wind plasma and IMF observations in the Earth's foreshock (INTERBALL-1/MAGION-4/IMP 8/GEOTAIL/WIND), poster, *EOS 80*, S267, 1999.

Francia, P., S. Lepidi, U. Villante, and A. Lazarus, Geomagnetic response to continuous solar wind pressure variations during northward interplanetary magnetic field conditions, *EOS 80*, S304, 1999.

Lazarus, A. J., P. A. Dalin, and G. N. Zastenker, Ion flux (pressure) pulses in the solar wind observed from the INTERBALL-1, Wind and other spacecraft. Part 1. Solar origins and interplanetary features, *Dynamics of the Magnetosphere (INTERBALL)* conference, Zvenigorod, Russia, February 8-13, 1999.

Lepping, R. P., D. Berdichevsky, A. Szabo, L. F. Burlaga, B. J. Thompson, F. Mariani, A. J. Lazarus, and J. T. Steinberg, Typical and unusual properties of magnetic clouds during the Wind era, poster, *EOS 80*, S267, 1999.

Posner, A., V. Bothmer, M.-B. Kallenrode, H. Kunow, B. J. Thompson, R. F. Forsyth, J. T. Gosling, B. Heber, A. J. Lazarus, R. J. Marsden, R. Muller-Mellin, T. R. Sanderson, and A. Szabo, Coronal sources, 3-D structure and evolution of CIRs during the onset of a new solar cycle: SOHO, Wind, and Ulysses observations, to be presented at the *IUGG/IAGA meeting*, Birmingham, England, July 19-30, 1999.

Sibeck, D. G., S. Kokubun, K. Kudela, A. J. Lazarus, R. P. Lepping, R. Lin, T. Mukai, T. D. Phan, S. Romanov, J. Safrankova, and D. J. Williams, The foreshock's effect on solar wind input into the magnetosphere, invited talk, *EOS 80*, S264, 1999.

Steinberg, J. T., J. T. Gosling, D. J. McComas, R. M. Skoug, R. L. Tokar, A. J. Lazarus, and K. I. Paularena, ACE and Wind: Comparison of solar wind proton and alpha particle measurements, *EOS 80*, S264-S265, 1999.

Zastenker, G. N., M. N. Nozdrachev, J. Safrankova, Z. Nemecek, K. I. Paularena, A. J. Lazarus, R. P. Lepping, T. Mukai, and S. Kokubun, Plasma and magnetic field variations in the magnetosheath: INTERBALL-1/MAGION-4/IMP 8/GEOTAIL/Wind observations, invited talk, *EOS 80*, S264, 1999.

Lepping, R. P., D. Berdichevsky, A. Szabo, C. Arqueros and A. J. Lazarus, Profile of a Generic Magnetic Cloud at 1 AU for the Quiet Solar Phase: Wind Observations, *EOS*, 2000.